Transfer information

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Project number : 20150095
Project name : Manual for Flaresim-Ver 4.0
Principal (client) : Internal use

Attachment (Reference doc.) : Draft manual for Flaresim (Gas Dispersion)
Attachment (Reference doc.) :
Attachment (Reference doc.) :
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Transfer information :

Process add your remark amd comments

* A = Action / I = For information

Transfer information to		Initial	Action *
☐ Projects	(X)		
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☐ Software	(S)		
☐ Piping	(P)		
☐ Mechanical	(M)		
☐ Civiel	(C)		
☐ Structural	(C)		
☑ Process	(T)	EBE	A
☐ HVAC	(W)		
☑ Process		HHA	I
☑ Process		GJR	I

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Reply to: All recipients and file the original incl. attachments in the Project File

Document number : 20150095
Revision : A
Date : 05.02.2015

HANDY MANUAL
Program "FLARESIM"
(Version 4.0)

Gas Dispersion

Issue	:	Feb. - 2015		
Status	:	For Process Department Internal Use		
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Document No:
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Table of Contents

Introduction

Flaresim includes two types of gas dispersion model intended for two different types of analysis:

- A jet dispersion calculation models dispersion of flared fluid close to the tip to identify the potential for dangerous gas concentrations in flame out conditions.
- A Gaussian dispersion calculation models dispersion of flared fluid or combustion products over longer distances.

The purpose of this document is to illustrate how to use each of these models and to analyse the gas dispersion around the flare in normal operation and flame out conditions.
The examples begin with gas jet dispersion analysis of relieved fluid and the dispersion of H2S in the event of a flame out condition and with the dispersion of combustion gases from burning. The examples attempt to highlight multiple dispersion objects carried out for different calculations.

- Example 1 – Gas Jet Dispersion
- Example 2 – H2S Gas Gaussian Dispersion Contour Plot
- Example 3 – Combustion Gases Gaussian Dispersion Line Plot

Flaresim Dispersion is applicable to analysis a single pollutant or multiple pollutants. The source of pollutants is either the combustion gases or the components in the relieved fluid.

Gas Dispersion

The Dispersion provides a Gaussian dispersion calculation to model the dispersion of combustion gases from burning flares and dispersion of relieved fluid in the event of a flame out condition. Gaussian dispersion is a simple model of gas dispersion appropriate for a first pass screening of emissions from a flare system. In its current implementation in Flaresim it is suitable for buoyant fluids only and does not include modeling of terrain or structure effects, both of which can have a significant impact on dispersion results.

Example 1 – Gas Jet Dispersion

The jet dispersion analysis for flammable gas concentrations is based on the Cleaver & Edwards jet dispersion model which is regarded as a reasonable model for concentrations close to the source.

In this example gas jet dispersion will be studied in case when the flammable gas concentrations around the flare in the event of a flame out.

The following data will be used in the example.

Flared Fluid	
Methane	0.9 mole frac
Ethane	0.08 mole frac
H2S	0.02 mole frac
Temperature	75 °C
Ref Pressure	1.013 bara
Flow	50,000 kg/hr

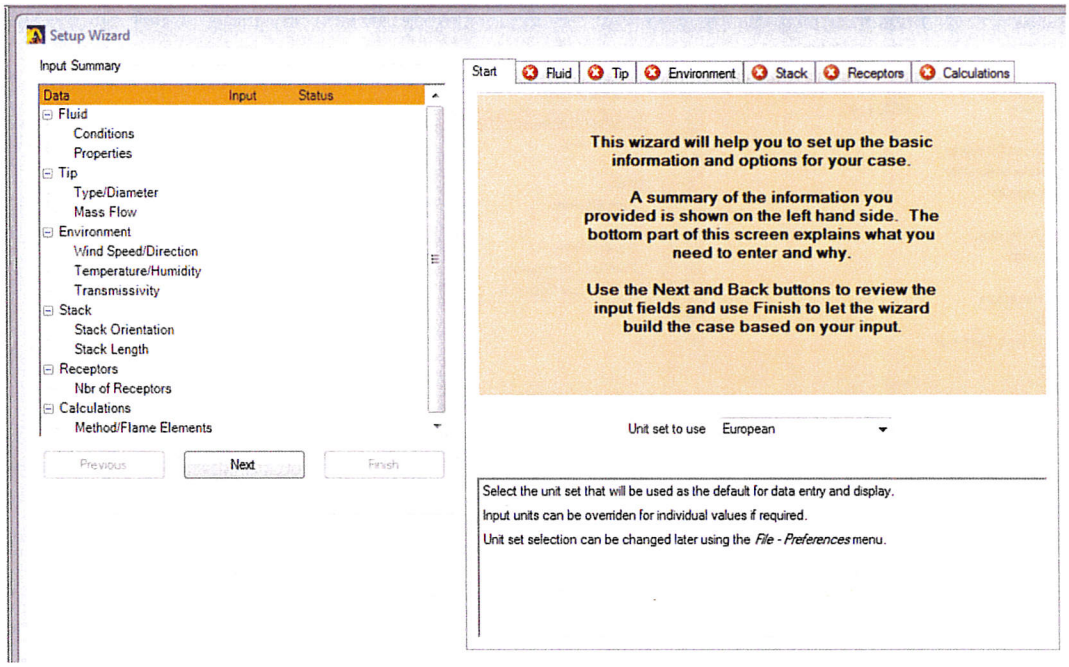
Mechanical Data	
Tip Diameter	387.4 mm (16 in)
Tip Length	1 m
Stack location	At origin (0, 0, 0)
Stack Length	20 m
Stack orientation	Vertical

Environment Data	
Temperature	15 °C
Wind	10 m/s from North

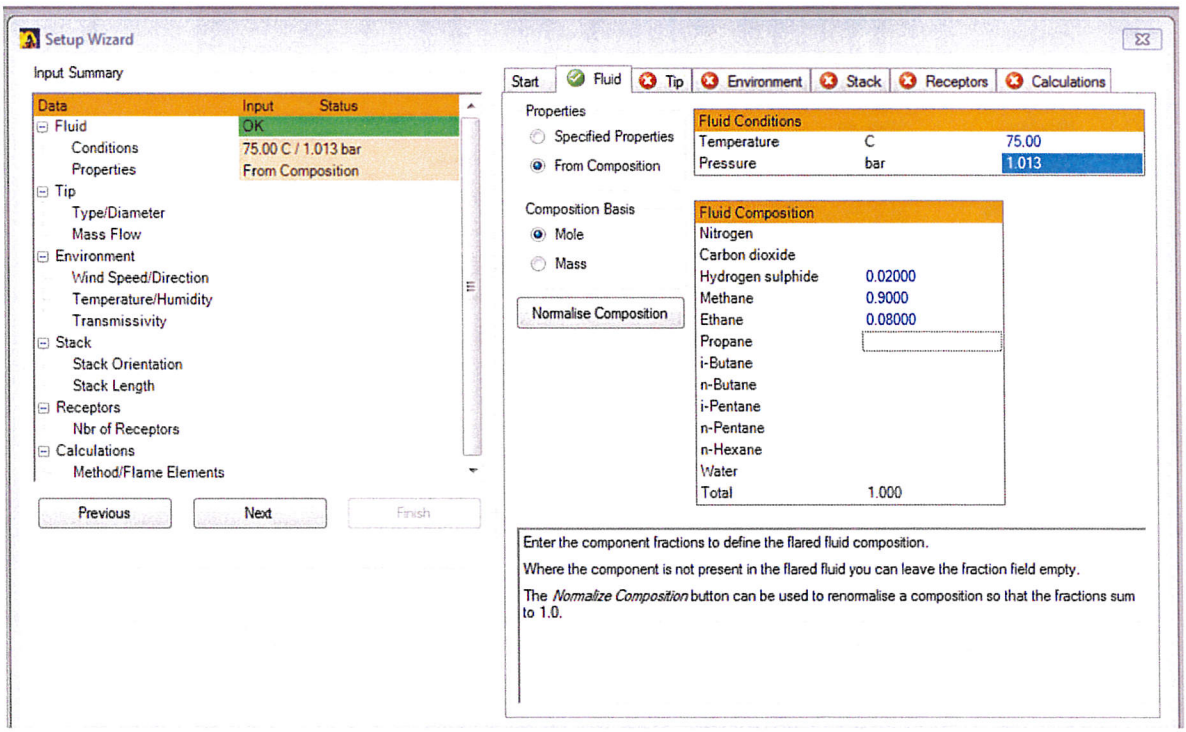
Initial Setup

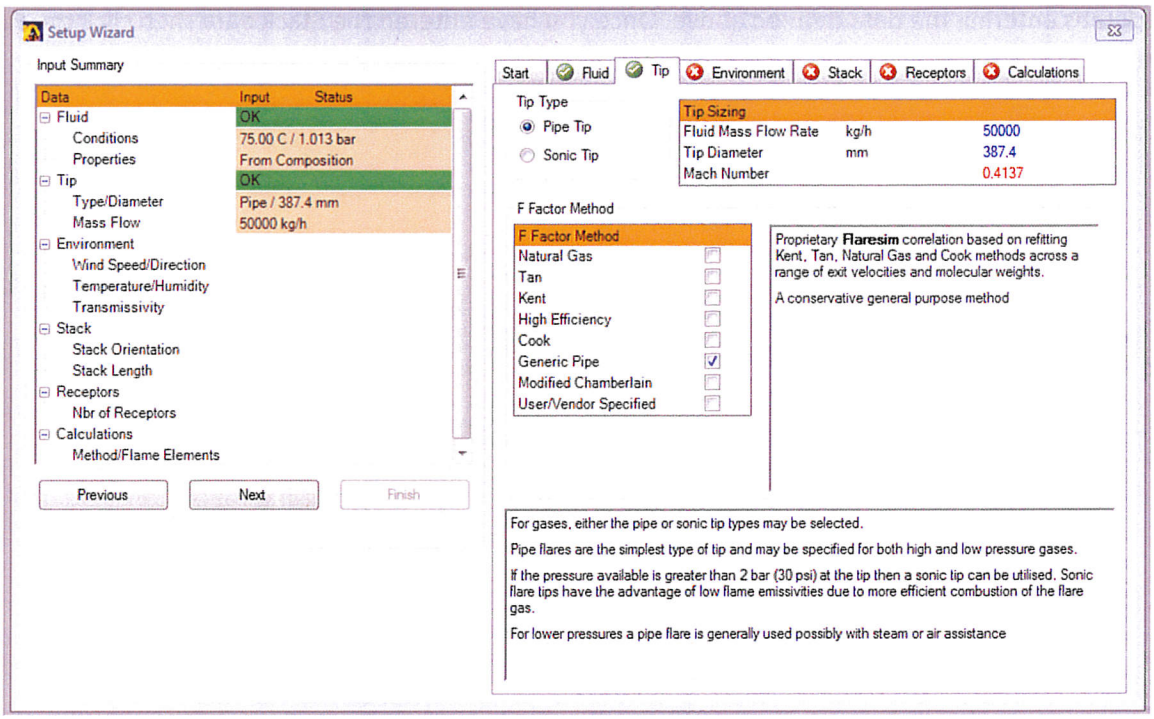
1. Start the Flaresim program.

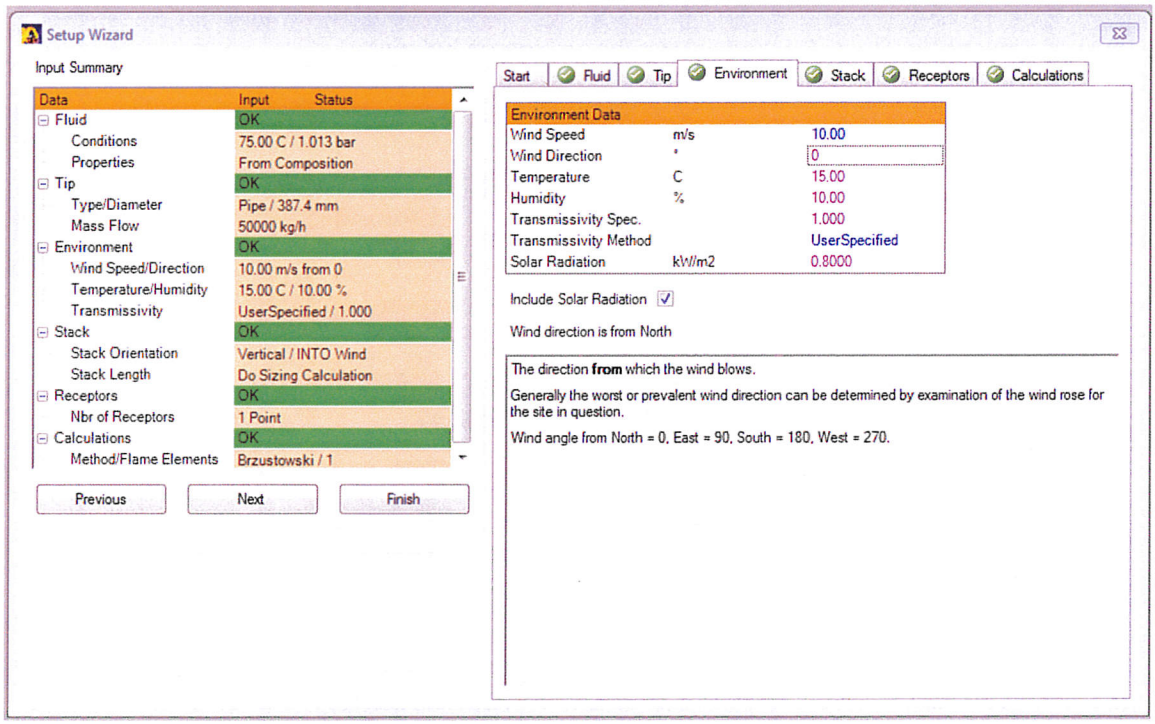
2. In the opening, set the unit to European Field as shown. Work through the Fluid, Tip, Environment and Stack tabs entering the data defined above. Once you have entered the Stack data then click the Finish button.

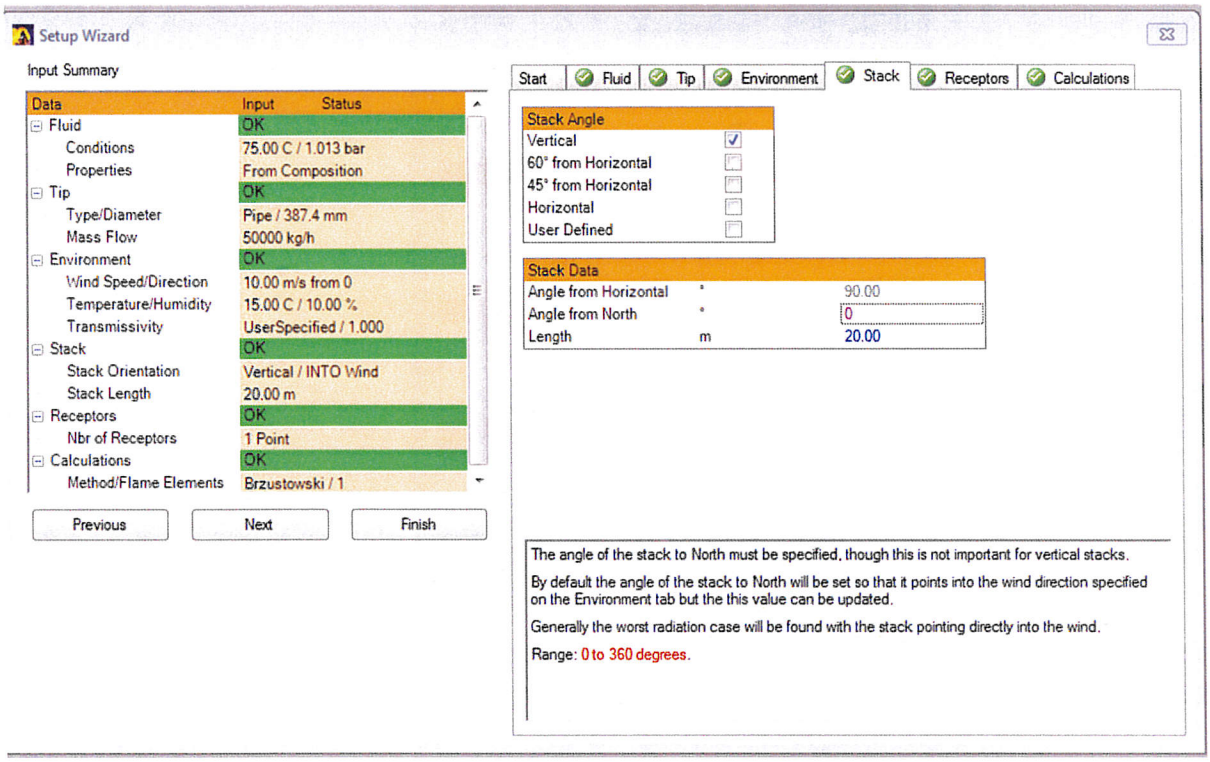


The finished view of the Fluid, Tip, and Stack tabs are shown below:




Setup Wizard
Input Summary
Data Input Status
Fluid OK
Conditions 75.00 C / 1.013 bar
Properties From Composition
Tip OK
Type/Diameter Pipe / 387.4 mm
Mass Flow 50000 kg/h
Environment
Wind Speed/Direction
Temperature/Humidity
Transmissivity
Stack
Stack Orientation
Stack Length
Receptors
Nbr of Receptors
Calculations
Method/Flame Elements
Previous
Next
Finish
Start
Fluid
Tip
Environment
Stack
Receptors
Calculations
Tip Type
Pipe Tip
Sonic Tip
Tip Sizing
Fluid Mass Flow Rate kg/h 50000
Tip Diameter mm 387.4
Mach Number 0.4137
F Factor Method
F Factor Method
Natural Gas
Tan
Kent
High Efficiency
Cook
Generic Pipe
Modified Chamberlain
User/Vendor Specified
Proprietary Flaresim correlation based on refitting Kent, Tan, Natural Gas and Cook methods across a range of exit velocities and molecular weights.
A conservative general purpose method
For gases, either the pipe or sonic tip types may be selected.
Pipe flares are the simplest type of tip and may be specified for both high and low pressure gases.
If the pressure available is greater than 2 bar (30 psi) at the tip then a sonic tip can be utilised. Sonic flare tips have the advantage of low flame emissivities due to more efficient combustion of the flare gas.
For lower pressures a pipe flare is generally used possibly with steam or air assistance

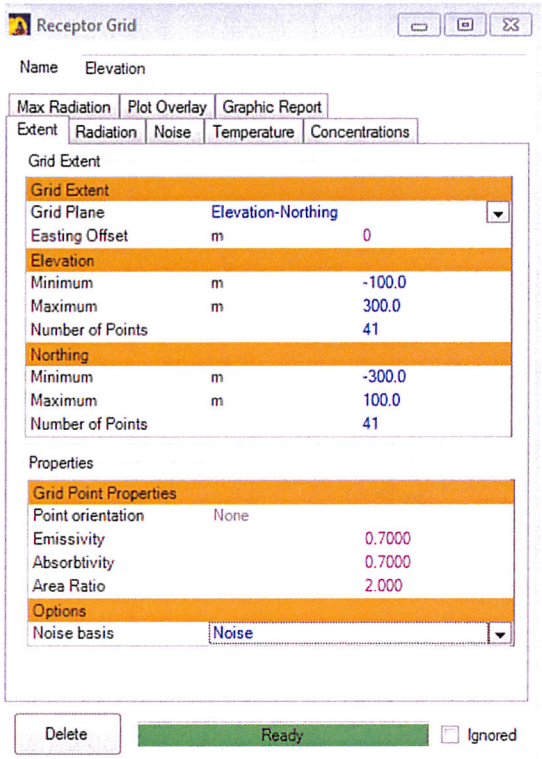

Setup Wizard
Input Summary
Data Input Status
Fluid OK
Conditions 75.00 C / 1.013 bar
Properties From Composition
Tip OK
Type/Diameter Pipe / 387.4 mm
Mass Flow 50000 kg/h
Environment OK
Wind Speed/Direction 10.00 m/s from 0
Temperature/Humidity 15.00 C / 10.00 %
Transmissivity UserSpecified / 1.000
Stack OK
Stack Orientation Vertical / INTO Wind
Stack Length Do Sizing Calculation
Receptors OK
Nbr of Receptors 1 Point
Calculations OK
Method/Flame Elements Brzustowski / 1
Previous
Next
Finish
Start
Fluid
Tip
Environment
Stack
Receptors
Calculations
Environment Data
Wind Speed m/s 10.00
Wind Direction ° 0
Temperature C 15.00
Humidity % 10.00
Transmissivity Spec. 1.000
Transmissivity Method UserSpecified
Solar Radiation kW/m2 0.8000
Include Solar Radiation
Wind direction is from North
The direction from which the wind blows.
Generally the worst or prevalent wind direction can be determined by examination of the wind rose for the site in question.
Wind angle from North = 0, East = 90, South = 180, West = 270.



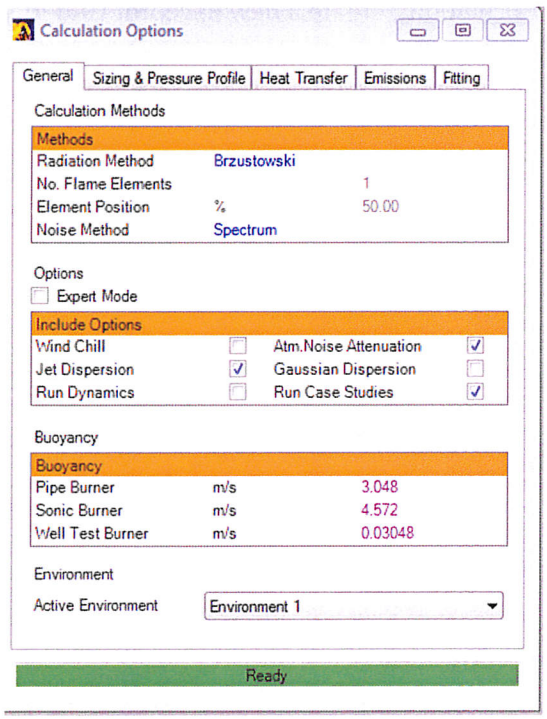
3. Before enabling the jet dispersion calculations, create a new Receptor Grid to see the results more clearly. Select the Receptor Grid branch in the Case Navigator and click the Add button. In the new view enter the following data.

   Name = Elevation
   Grid Plane = Elevation-Northing
   Grid Offset = 0 m
   Elevation Minimum = -100 m
   Elevation Maximum = 300 m
   Northing Minimum = -300 m
   Northing Maximum = 100 m

   Leave remaining values at defaults.

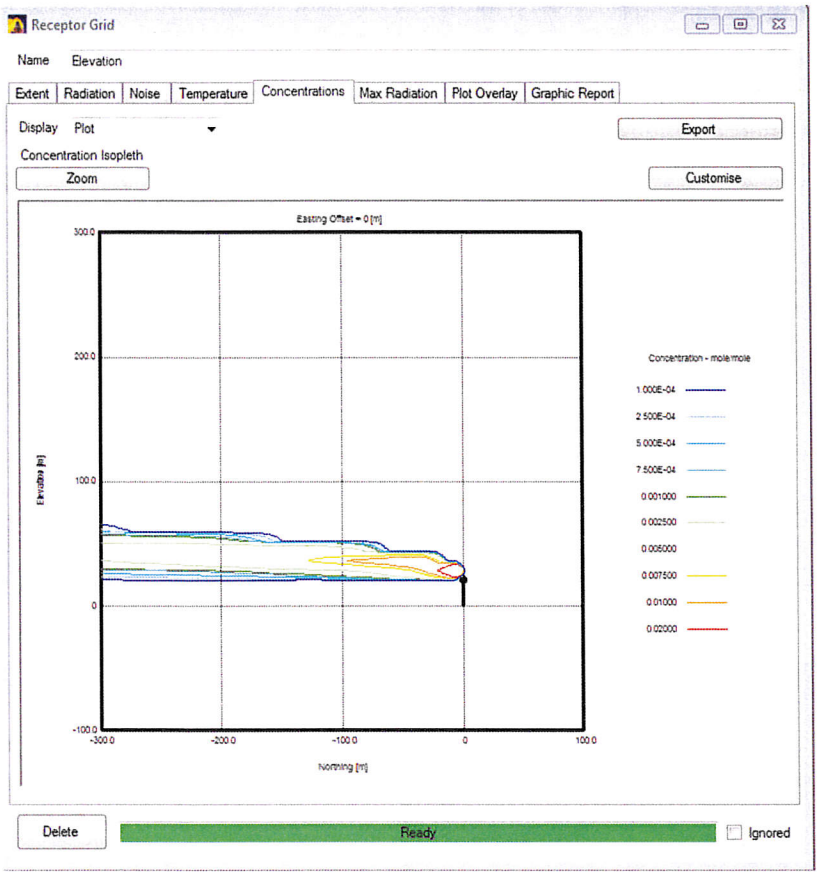


4. Open the Calculation Options view by selecting it in the Case Navigator and clicking the view button. Select the check box labeled Jet Dispersion in the Include Options section of the General Tab.



Initial Calculations

The design is ready to run. Click the Calculate button. The background of the Errors/Warnings log will be yellow indicating a warning message. Checking this it warns of the jet interacting with the ground at a distance of 2152m which is not a problem.



The jet dispersion calculation shows the concentrations of the flare fluid in the event of a flame out and is useful for establishing the regions in which a flammable gas concentration may be obtained.

Example 2 – Gas Gaussian Dispersion Contour Plot

The Gaussian dispersion calculates the combustion gases and flared fluid over longer distances and uses a simpler theoretical model that does not include detailed terrain effects.

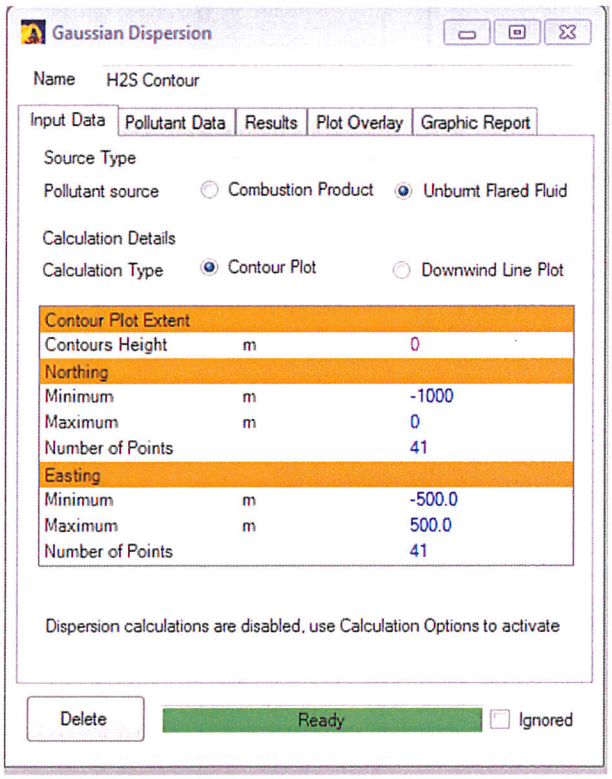
In this example the dispersion of H2S from the flare tip in the event of a flame out will be studied.

Initial Setup

1. Create a Dispersion Object by selecting the Dispersion branch in the Case Navigator and clicking the Add button. In the Dispersion view enter the following data on the Input Data tab as shown below.

Name = H2S Contour
Pollutant Source = Flared Fluid
Calculation Type = Contour Plot
Contours Height = 0 m
Northing Minimum = -1000 m
Northing Maximum = 0 m
Easting Minimum = -500 m
Easting Maximum = 500 m
Number of points, Northing and Easting = 41

2. On the Pollutant Data tab select the H2S component only. For a contour plot, only one component can be selected.

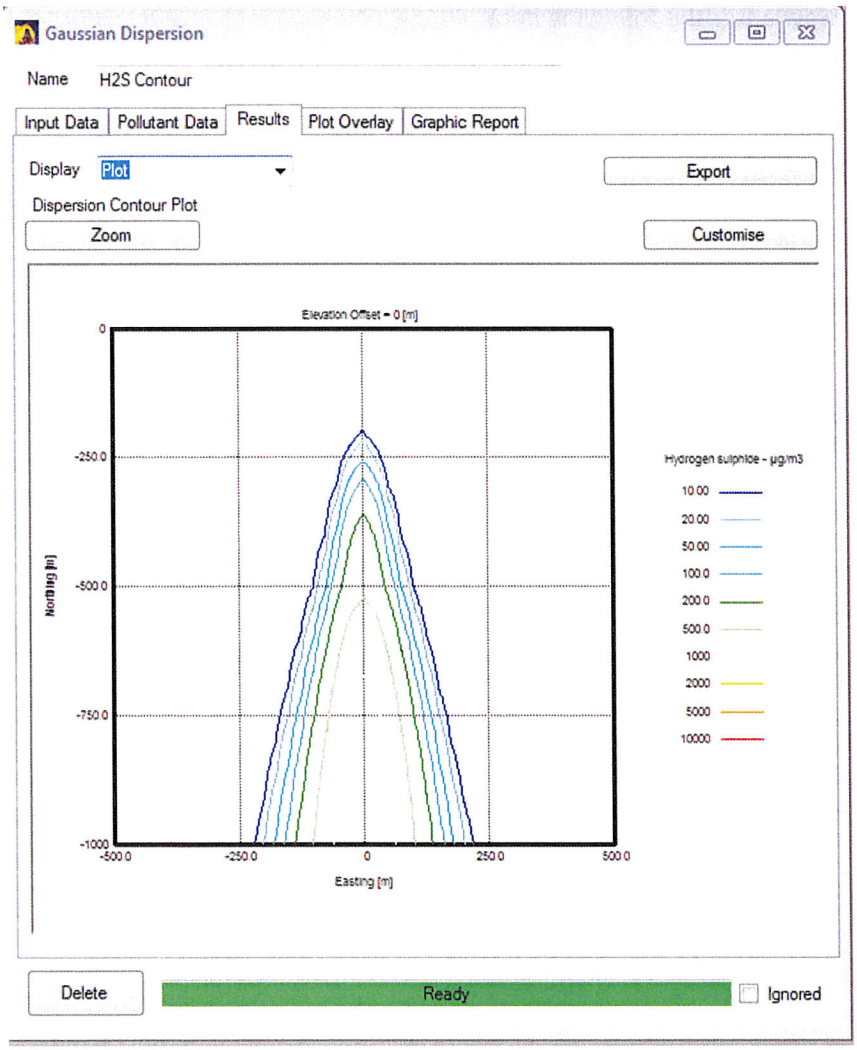


3. Open the Calculation Options view and select the Gaussian Dispersion checkbox to enable these calculations.

Initial Calculations

The design is ready to run. Click the Calculate button.

Select the Results tab and then the Plot option for the display. The plot shows the ground level concentration contours for H2S downwind of the stack as shown below.



Example 3 – Gas Gaussian Dispersion Line Plot

In this example the downwind concentrations of pollutants in the combustion gases of the flare when it is operating will be studied.

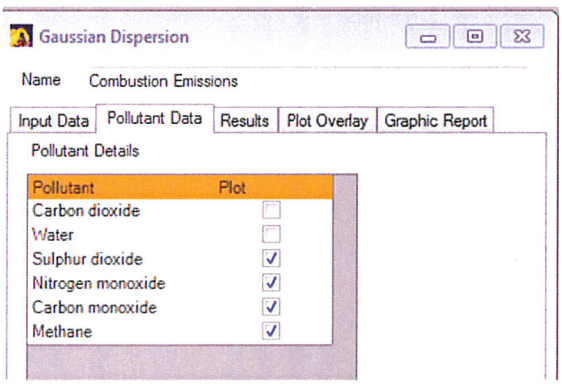
Initial Setup

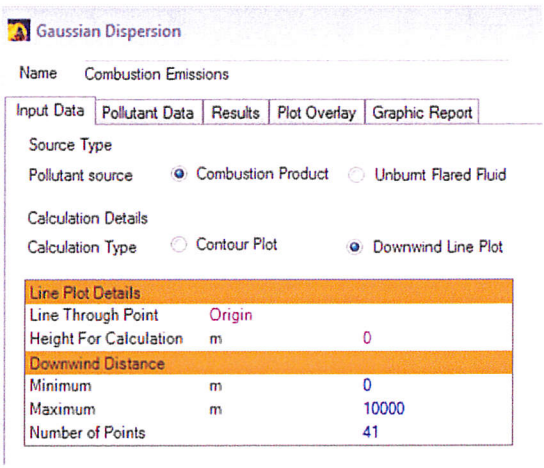
In the Case Navigator select the Dispersion branch and click Add to create a new dispersion object.

1. In the Input Data tab of its view enter the following data.

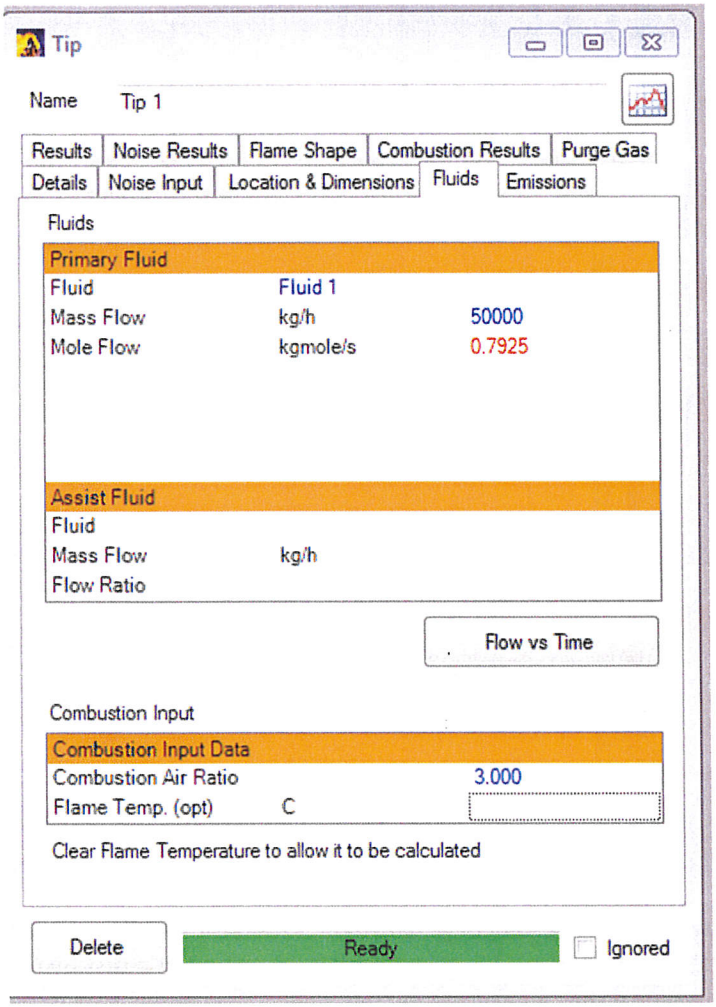
Name = Combustion Emissions
Pollutant Source = Combustion Gas
Calculation Type = Downwind Line Plot
Line through Point = Origin
Height for Calculation = 0 m
Downwind Distance Minimum = 0 m
Downwind Distance Maximum = 10000 m
Number of points = 41

2. Select the Pollutant tab and select the SO2, NO, CO and Methane pollutants for calculation by checking the box alongside these components.





3. Since the dispersion of the combustion gases will be dependent on the flame temperature, it can be set. Hence open the Tip View and select the Fluids tab. At the bottom of this view you may input a value for the flame temperature or clear the specified value to allow it to be calculated from the specified combustion air ratio.
4. Set the Combustion Air ratio to 3.0 and clear the specified flame temperature.

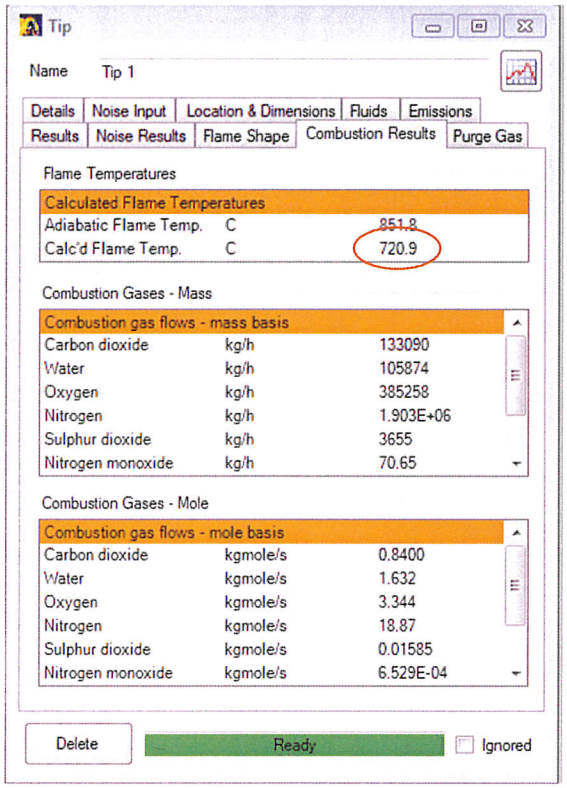


5. Open the Environment view and set the Atm. Stability Class to PasquillB.

Initial Calculations

The design is ready to run. Click the Calculate button.

Return to the Combustion Gas Results tab of the Tip view to see the calculated flame temperature of 721 °C and the combustion gas compositions.



In the Combustion Gas dispersion view go to the results page and select the plot result to view the results as shown below. The peak concentration of SO2 is calculated at 68 µg/m3 at a distance of approximately 1500 m downwind of the flare tip